Oct. 4, 1938. E. E. KLEINSCHMIDT ET AL 2,131,741

FACSIMILE PRINTING TELEGRAPH SYSTEM AND APPARATUS

Original Filed Aug. 4, 1930 3 Sheets-Sheet 1

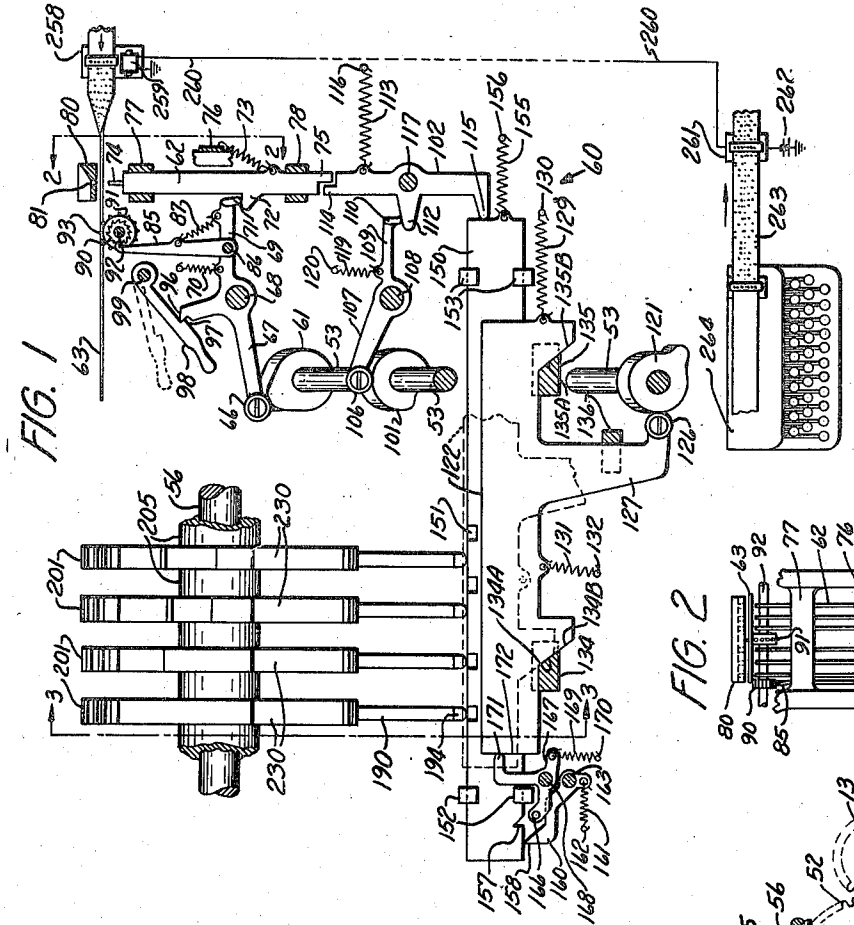


FIG. 1

FIG. 2

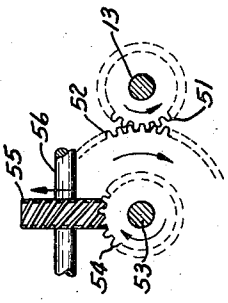


FIG. 4

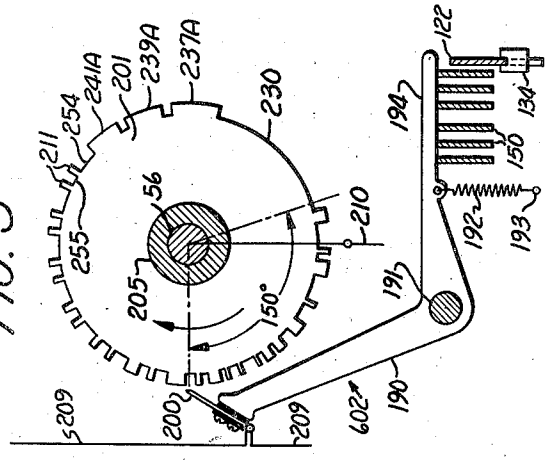


FIG. 3

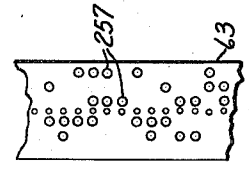


FIG. 5

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FACSIMILE PRINTING TELEGRAPH SYSTEM AND APPARATUS

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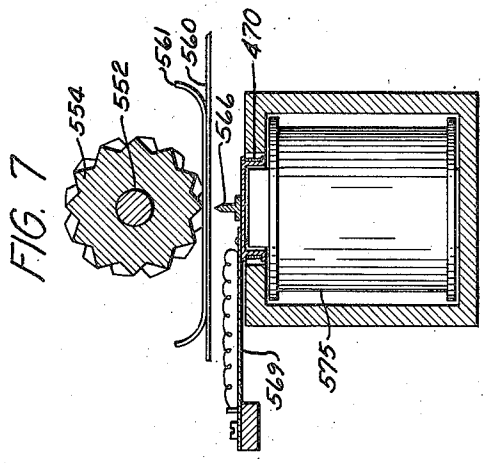


FIG. 7

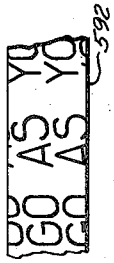


FIG. 10



FIG. 9

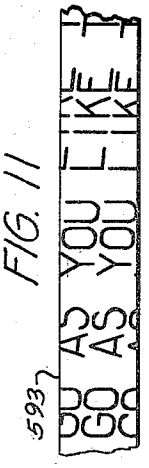


FIG. 11

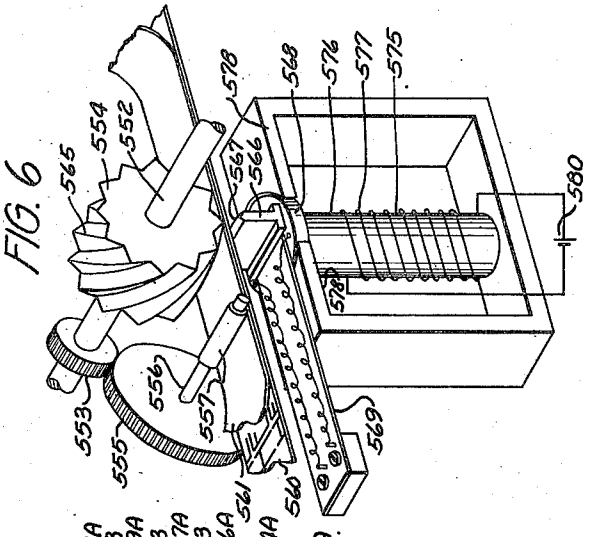


FIG. 6

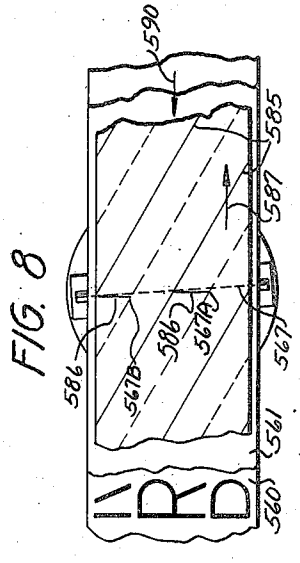


FIG. 8

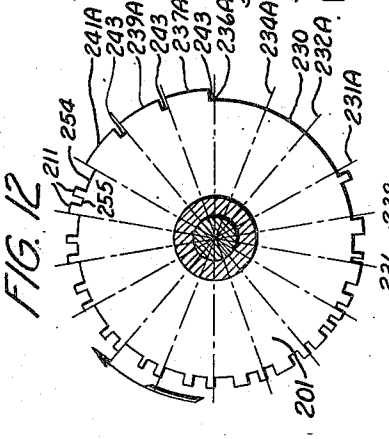


FIG. 12

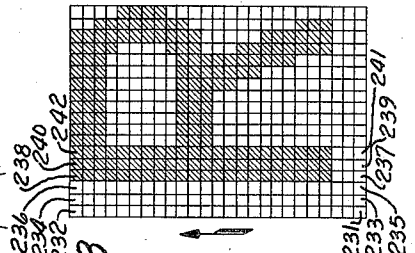


FIG. 13

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FACSIMILE PRINTING TELEGRAPH SYSTEM AND APPARATUS

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FIG. 16

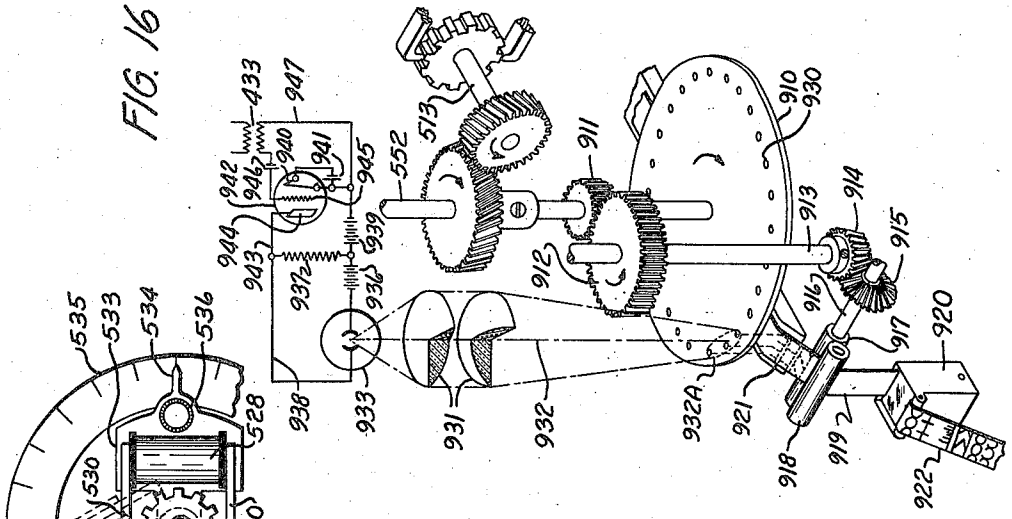


FIG. 15

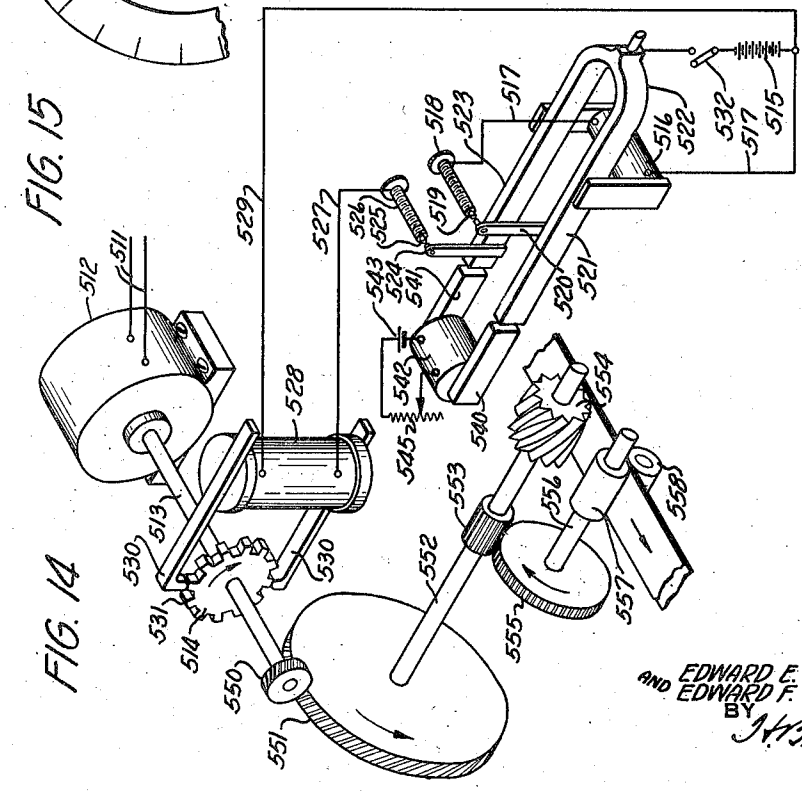


FIG. 14

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UNITED STATES PATENT OFFICE

2,131,741

FACSIMILE PRINTING TELEGRAPH SYSTEM AND APPARATUS

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Original application August 4, 1930, Serial No. 475,264. Patent No. 2,046,328, dated July 7, 1936. Divided and this application July 19, 1934, Serial No. 735,948

21 Claims. (Cl. 178—5)

This invention pertains to printing telegraph systems and more particularly to facsimile telegraph systems and apparatus in which signal codes representing scanning analyses of letters and other characters are transmitted character by character to form a directly legible printed line character and in which successive characters occupy approximately equal lineal units of space in the line.

This application is a division of application Serial No. 475,264 filed August 4, 1930 which issued on July 7, 1936 as Patent No. 2,046,328.

An object of the present invention is to provide a simple, efficient, and reliable facsimile printing telegraph apparatus wherein special control or synchronizing impulses over the line transmission conductor are not required nor any equivalent thereof, thereby materially simplifying the apparatus.

A further object is to provide a facsimile printer so constructed that a legible record is attained even though the speed of the printer may vary appreciably from the speed of the transmitting unit to which it is responsive.

The above and other objects are attained by providing a facsimile receiving mechanism which in response to facsimileing signals received over the transmitting path will produce records which are essentially duplicates, one of which records may be at times illegible but at least one of which records will be at all times legible. In the operation of the mechanism herein disclosed should the speed of the receiving printer be exactly accurate, the received intelligence will be recorded in a line parallel to the edge of the tape or other recording surface and any variation in speed will result in a slight sloping of the line of the record at an angle upward or downward so that the line of the record will pass off the edge of the tape, but in such an occurrence a duplicate record will be produced which lies fully upon the surface of the receiving and recording tape.

A better understanding of the invention may be had from the following description, taken in conjunction with the accompanying drawings wherein,

Fig. 1 shows a schematic arrangement of the essential mechanical parts of a tape controlled transmitter embodied in this invention;

Fig. 2 is a broken elevation taken on line 2—2 of Fig. 1;

Fig. 3 is a section of permutation bars, selection bail, brush carriers, and code discs of the mechanism of Fig. 1 taken on line 3—3 of Fig. 1;

Fig. 4 shows a mechanical detail of gearing interconnecting apparatus in Fig. 1;

Fig. 5 is a plan of a tape adapted to control the apparatus of Fig. 1;

Fig. 6 is a perspective of receiving apparatus;

Fig. 7 is a section of printing apparatus of Fig. 6 taken substantially centrally thereof;

Fig. 8 is a diagram of the printing elements of the receiver showing a record tape printing armature member, and a development of the printing edges of the spirally fluted printing wheel for producing duplicate images upon the receiving tape;

Fig. 9 shows a specimen of receiving tape produced at equal speeds;

Fig. 10 shows a specimen of receiving tape with the receiver running faster than its controlling transmitter as calculated in equivalent cycles transmitted and received;

Fig. 11 shows a similar tape as produced when the receiver is running at a comparatively slower speed;

Fig. 12 is a side view of a code disc which forms a part of the transmitter of Fig. 1, shown also in Fig. 3 and elsewhere;

Fig. 13 is a diagram showing the analysis of a character according to a method for prescanning, the character shown being that character transmitted by the specific code disc shown in Fig. 12;

Fig. 14 shows a receiving device having speed controlled mechanism whose speed is regulated by a tuning fork;

Fig. 15 shows mechanism for adjusting the phase relation of the speed regulated shaft as related to the cycle of the incoming signals by manually retarding or accelerating the rotation of the speed regulated shaft, and

Fig. 16 shows a photo-recording mechanism for producing double images.

Referring first to Fig. 4, motor driven shaft 13 carries pinion 51 which meshes with gear 52 on power cam shaft 53 of Fig. 1. Shaft 53 carries spiral gear 54 which meshes in the spiral gear 55 on shaft 56 and thus drives transverse shaft 56 of the transmitter of Fig. 1 at the same angular speed as cam shaft 53.

Referring to Fig. 1, a code transmitter 60 is driven by a power cam shaft 53 which carries three cams. A first cam 61 controls the action of feeler bars 62 of which there are six in the device as shown, the feeler bars 62 being sufficient in number to detect all of the code holes in control tape 63. Apparatus herein illustrated is adapted to use a six-hole cross-perforated tape, although the device may be arranged to be controlled from any desired form of tape. Cam 61

engages roller 66 on cam follower 67 pivoted at 68 to the transmitter frame. Cam follower 67 is under tension of spring 70 and has arm 69 with transverse flange 71 which engages six lugs 72 on the six feeler bars 62. Each feeler bar 62 is provided with an individual spring 73 urging it upward, with a tape testing pin 74 and with a stop lug 75. Springs 73 extend to the center frame slide guides 77 and 78 fixed in the frame. Tape at 76 and the six feeler bars operate freely in guide 80 is perforated at 81 opposite each tape testing pin 74.

Arm 69 carries pawl 85 attached pivotally at 86 and under tension of spring 87 withdraws the pawl against the teeth of ratchet 90. The ratchet 90 and tape feed sprocket wheel 91 are fixed to shaft 92 which is journaled in the frame. Pins on feed wheel 91 engage said holes in tape 63 in well-known manner to feed the tape in operation.

Follower 67 has a stop tooth 96 engageable by tooth 97 in a manually controlled lever 98 pivoted at 99 to the frame of the transmitter. With shaft 53 and cam 61 in operation and with lever 98 in the full line position shown, follower 67 is held from movement as cam 61 rotates and operation of the transmitter is prevented. With lever 98 moved to the dotted line position shown, follower 67 is freed for movement under influence of spring 70 and cam 61, and transmitting operations may proceed under control of tape 63.

A second cam 101 carried by shaft 53 controls the action of transfer levers 102 which are equal in number to the tape feeler bars 62 and are controlled thereby. Cam 101 engages roller 106 on cam follower 107 pivotally mounted at 108 to the frame. Cam follower 107 has an arm 109 with transverse flange 110 which engages six lugs 112 on the six transfer levers 102. Each lever 102 is provided with individual spring 113, with a testing finger 114 and with a power lug 115. Springs 113 are secured to the transmitter frame at 116 and the six transfer levers are pivotally mounted for independent movement upon a common pivot shaft 117 fixed in the frame. Cam follower 107 is under tension of spring 119 secured to the frame at 120.

A third cam 121 carried by shaft 53 engages roller 126 on cam follower arm 127 formed integrally with bail 122. Bail 122 is under tension of two springs, spring 129 attached to the frame at 130 and spring 131 attached to the frame at 132. Bail 122 operates freely in longitudinal and vertical directions in slide guides 134, 135, and 136 fixed to the transmitter frame. Guides 134 and 135 are provided with inclined cam surfaces 134A and 135A which are engaged by inclined edges 134B and 135B respectively of bail 122. As cam 121 rotates, the cooperation of cam 121, surfaces 134A, 134B, edges 135A, 135B, and springs 129, 131 shifts bail 122 into and out of its dotted line position, the shift being made momentarily and once for each rotation of shaft 53.

Six permutation bars 150 provided with selecting notches 151 slide in slotted guides 152 and 153 fixed to the transmitter frame. Each bar 150 is provided with an individual spring 155 secured to the frame at 156. Each bar 150 is individual to and controlled by each of the six transfer levers 102, and springs 155 draw the six bars 150 severally against the lugs 115 which determine the normal position of rest of the bars, the normal position of levers 102 and lugs 115 being determined by springs 113 and by the flange 110 of follower 107, whose position is determined by engagement of roller 106 and cam 101.

Each bar 150 has a locking notch 157 adapted to be engaged by point 158 of a latch 160 of which there are six individual to six bars 150. Secured to each latch 160 is a spring 161 attached also to the transmitter frame at 162. The six latches 160 are pivotally mounted upon a common pivot 163 fixed in the frame and are crossed by a striker pin 166 carried by a restoring bell crank 167 pivotally mounted at 168 upon the frame and under tension of spring 169 attached to the frame at 170. Bell crank 167 rotates on its pivot 168, and extension 171 thereof at all times slidably engages end 172 of selector bail 122. Notches 151 of bars 150 are preferably arranged in a manner similar to the permutation code bars commonly used in tape printing telegraphs and are preferably arranged to operate under control of permutation code perforations in tape 63.

Referring to Fig. 3 in connection with Fig. 1, a series of bell cranks 190, one for each character to be transmitted, are pivotally mounted upon a common pivot shaft 191. Each bell crank 190 has an individual spring 192 secured to the frame at 193 which springs urge arms 194 of bell cranks 190 into engagement with the six permutation bars 150, thus conditioning the bell cranks to be selectively controlled by sets of aligned notches 151 of bars 150 in accordance with control perforations in tape 63.

Each bell crank 190 carries an insulated brush 200. The brushes 200 contact severally with code discs 201, one for each character or signal to be transmitted, all rigidly secured to shaft 56 and spaced apart by collars 205. Each code disc 201 has associated with it an individual brush 200 with its operating member 190.

All the brushes 200 are connected to a common wire 209 and all code discs 201 are connected electrically through shaft 56 and through the transmitter frame to a common wire 210. Each code disc has a high radius or contact surface 211 at each point where a signal is to be transmitted. Contact surfaces 211 are arranged on each code disc in such manner as to transmit the desired signals.

Code discs 201 are designed according to a novel method of prescanning in which characters or symbols to be transmitted are divided into any desirable number of transmitting units of areas and in which the several unit areas thus created are assigned in order of scanning to the periphery of the disc 201, either the dark areas or the light areas of the character being represented by the high surfaces 211 to engage the brush 200 to send a signal, depending upon the method of transmission adopted.

By way of example a prescanning of the letter "R" together with the area of space between the letter and the preceding letter is shown in Figs. 12 and 13. The total area of the letter and space there shown is divided into 450 unit areas arranged in eighteen vertical strips of twenty-five units each. As shown in Fig. 13, the eighteen strips are laid off in eighteen angular sectors on the code disc, and each angular sector is divided into twenty-five angular units each corresponding to a unit area of the corresponding vertical strip. The code disc periphery is then executed by recessing the corresponding disc unit sections of each sector where the respective scanning unit areas are light, thus producing raised surfaces such as 211 where the scanning units are dark. A blank interval is left below and/or above each letter or character, shown in Fig. 13 as three lower horizontal blank rows. Prescan-

ning or generation of the code begins at unit area 231 in Fig. 13 and progresses vertically to area 232. Since all of the unit areas in this strip are white, the twenty-five units of the first sector between radii 231A and 232A of Fig. 12 are recessed, forming a portion of a continuous low-radius arc 230. Prescanning then proceeds for the next sector beginning with unit area 233 and ending with unit area 234 of the second vertical strip and between radii 232A and 234A on the code disc periphery of Fig. 12. All areas of the second strip being white, the second sector of the code disc is also completely recessed. Prescanning then proceeds for the third sector beginning with area 235 and ending with area 236 of Fig. 13, resulting in the third recessed sector between radii 234A and 236A. Prescanning proceeds from unit area 237 to unit area 238 then 239 and 240, and 241 and 242, completing three groups of twenty-two black unit areas each preceded by three white unit areas resulting in corresponding raised portions 237A, 239A, and 241A, each preceded by a recessed sector 243 as shown in Fig. 12. Prescanning proceeds in like manner for the seventh sector, giving thirteen white unit areas for recessed arc section 254 of disc 201, then three black unit areas for first arc 211, six white unit areas corresponding to recessed arc 255, and three black unit areas for final arc 311 of the seventh sector of disc 201. In this manner prescanning proceeds through the remaining eleven strips of Fig. 13 to complete the periphery of code disc 201 of Fig. 12, shown also in Fig. 3.

In like manner each other code disc is developed to transmit the other desired characters. Every letter or character to be transmitted is preceded by the desired space between it and the preceding letter so that every code disc comprises a letter space and character code, and the first three sectors of each disc are allotted to transmission of the letter space, thereby providing a depressed spacing arc 230 extending from radius 231A to 236A of Fig. 10 on each disc. The code discs are then fixed on shaft 56 in such manner that the starting arcs 230 are in alignment.

Controlling tape 63, Fig. 5, may be perforated in any well-known manner with successive rows of perforations 257 arranged in controlling combinations in accordance with a six-unit permutation code and with one or more rows of feed holes to be engaged by the pin on the tape feed wheel 91 of the transmitter.

For purposes of remote control, a magnetically controlled reperforator 258 controlled by signal selector magnet 259 is utilized. Selector magnet 259 is connected in line 260 which is in turn controlled by a six-unit permutation code tape transmitter 261 of any desired construction and which controls the transmission of code impulses to line 260 from battery 262 in accordance with perforations in control tape 263 formed in keyboard perforator 264 of any desired construction. As the receiving perforator 258 produces a duplicate of the tape 263 adjacent to the transmitting mechanism 60, it will be obvious that the keyboard perforator 264 and tape 263 may be utilized directly to control the transmitter 60 in place of the reproduced tape 63 if desired.

Operation of transmitter

To start transmission, the shafts 53 and 56 being in rotation and perforated tape 63 being in position in guide 80, manual lever 98 is lifted when apex of cam 61 is under roller 66, thus releasing cam follower 67. Notch 97 of lever 98 and detent 96 of cam follower 67 are so shaped that under the action of spring 70 the raising of lever 98 is prevented until roller 66 is on the peak of cam 61, thereby insuring initiation of transmission at the beginning of a cycle. With cam 61 in the position shown in Fig. 1, discs 201 will be in the position shown in Fig. 3 and cam roller 68 will be lowered during approximately 120° of angle of rotation of shaft 53. Rotation of cam 61 allows spring 70 to rotate cam follower 67 counterclockwise about its pivot 68 to lift flange 71 out of engagement with the six lugs 72 on tape feeler bars 62 which rise under influence of spring 73. When feeler bars 62 rise, should any feeler pins 74 register with any holes in tape 63, said pins will pass through said holes and each feeler bar 62 will rise to remove its stop lug 75 from the path of finger 114 on corresponding transfer lever 102. Accordingly feeler bars 62 will be positioned in a code combination in accordance with the controlling permutation code perforations.

Rotation of shaft 53 for approximately 110° from the zero position shown in Fig. 1 carries cam 121 into engagement with roller 126 to shift follower 127 and selector bail 122, thus moving said bail to dotted position. Vertical movement of the selector bail 122 causes it to engage arms 194 of all bell cranks 190 to raise the members clear of permutation bars 150 to permit setting of the bars immediately after the last transmitting arcs of all discs 201 have passed their respective brushes 200.

Movement to the left of bail 122 causes rotation of bell crank 167 about its pivot 168 which causes striker pin 166 carried thereby to engage and to depress all latches 160. This releases all operated permutation bars 150 and allows them to return to their right-hand position under action of their individual springs 155. Further rotation of shaft 53 to about 120° from zero angle next causes the low portion of transfer cam 101 to pass under roller 106, thus allowing spring 119 to rotate cam follower 107 counterclockwise lifting flange 110 out of engagement with lugs 112 to release the six transfer levers 102. At this point in the cycle of operations feeler bars 62 have assumed their selective positions in accordance with the code for the character to be transmitted and transfer levers 102 will be positioned accordingly. The transfer levers associated with the feeler bars 62 which are raised due to perforations in tape 63 are free to rotate clockwise under influence of their individual springs 113 which maintain lugs 112 in engagement with flange 110. Others of said transfer levers are retained in the position shown in Fig. 1 due to lugs 75 or feeler bars 62 contacting with lugs 114 on the transfer levers to prevent rotation of the transfer levers.

The transfer levers assume positions in accordance with the code for the character to be transmitted at or just after restoration of bars 150, and due to the engagement of lugs 115 of these transfer levers with the ends of permutation bars 150, said bars will be forced to assume a position in accordance with the code for the character to be transmitted.

Code bars 150 engaged by transfer levers 102 which are free to rotate clockwise will be forced to the left thereby to align slots 151 under one bar 194 of bell cranks 190. Movement of permutation bars 150 to the left in Fig. 1 aligns notches 157 in said moved bars with tips 158 of latches

160. When shaft 53 has rotated to say 140°, cam 121 will release roller 126 and bail 122 will return to its normal lowered position under influence of its springs 129 and 131. As bail 122 is lowered latches 160 engage the notches of operated bars 150 and bell crank 190 selected in accordance with the code of the character to be transmitted will fall into the aligned notches of the code bars 150 and will move the brush 200 thereon into engagement with one of the discs 201. Cam 101 restores transfer lever 107 and transfer levers 102 after cam 121 allows bail 122 to be lowered and after bars 150 are locked in their new positions.

The selected brush 200 approaches its individual disc at or immediately before the radius marked 236A in Fig. 12. The time interval in which all discs 201 rotate their arcs 230 from radius 231A to radius 236A through the contact point of their brushes 200 provides a transmission interval during which the movement of the receiving tape effects a space between consecutive characters, during which also a brush 200 which has been utilized for the completed character may be lifted and a brush selected to be utilized for the succeeding character may be brought into transmitting position. As the rotation of shaft 56 continues through its facsimileing angle of 300°, the selected character will be transmitted by signals similar to signals produced by direct scanning and during that transmission an overlap action will occur in the selecting mechanism of the transmitter 60. Transfer levers 102 will be restored by cam 101, feeler bars 62 will be restored by cam 61, and tape 63 will be advanced by rotation of sprocket wheel 91 and shaft 92 produced by movement of pawl 85 as arm 69 is lowered by cam 61. The transmitting mechanism thus is positioned for its next cycle of selection, which begins immediately as cam 61 lowers its follower 67, and the selection is completed in readiness for transfer to a predetermined bell crank 190 during the next interval while the low radius arcs 230 are passing brushes 200.

Receiving mechanism

The details of the receiving printing unit are shown in Figs. 6, 7 and 8, and now will be described.

Referring to Fig. 14, power mains 511 are connected to prime mover 512 which may turn shaft 513 bearing governor wheel 514.

Battery 515, magnet 516, wires 517, adjustment screw 518 with its contact 519 and the contact member 520 on arm 521 of the vibrator 522 form a self-interrupting energizing circuit for the magnet 516.

Battery 515, vibrator 522, arm 523, contact member 524, contact 525, adjustment screw 526, wire 527, magnet 528 and wire 529 form an energizing circuit for speed governing magnet 528. Pole pieces 530 are attached to magnet 528 and approach governor wheel 514 on opposite sides in such manner that two teeth 531 of the governor wheel may be under two pole pieces at the same time. Switch 532 closes the two circuits just traced.

Pole pieces 530 and magnet 528 are mounted upon plate 533 sleeved upon shaft 513 (see Fig. 15). A pointer 534 on plate 533 is associated with a fixed scale 535, and lock screw 536 with knurled head serves to lock plate 533 in adjusted position. This arrangement permits angular adjustment of pole pieces 530 around shaft 513 to effect orientation of the receiver.

Adjacent the ends of vibrating arms 521 and 523 are pole pieces 540 and 541 of magnet 542 energized by a circuit including battery 543 and adjustable resistance 545.

By the mechanism as above described, the speed of prime mover 512 is accurately and locally governed by the magnetic brake mechanism as follows: With switch 532 closed, vibrator 522 will operate, it being necessary at times to manually start the same. After operation of vibrator 522 is initiated it will be continuously maintained by the magnetic drive make and break circuit. Periodic energization of magnet 528 magnetizes poles 530 which will automatically maintain the speed of prime mover 512 constant by action of pole pieces 530 on teeth 531 of wheel 514. If prime mover 512 tends to speed up faster than the rate of vibration of fork 522 the periodic energization of magnet 528 will operate to retard the motor, since teeth 531 on wheel 514 will be pulled into registry with pole pieces 530 each time magnet 528 is energized. The same result occurs if the motor 512 slows up in its operation behind vibrator 522, and in this way the speed of the receiving mechanism is very closely regulated by the vibrator or tuning fork 522.

If the speed of the receiver is not exactly in synchronism with that of the transmitting mechanism, as will be apparent from an inspection of the printed tape at the receiver, adjustment of rheostat contact 545 will vary the magnetic effect of poles 540 and 541 on tines 521 and 523 to accelerate or retard vibration of the vibrator 522 to secure accurate synchronization.

Shaft 513 carries driving gear 550 which meshes with gear 551 on shaft 552. Shaft 552 carries and drives pinion gear 553 and printing or recording wheel 554. Pinion 553 meshes with and drives gear 555 on the shaft 556 which shaft bears and drives feed roller 557.

Referring to Figs. 6 and 7, feed roller 557 has a companion presser roller 558 (Fig. 14) suitably urged towards roller 557. Driven between the two rollers are two tapes 560 and 561. Tape 560 constitutes the record receiving surface and tape 561 is a pigment carrying tape such as carbon transfer paper or an ink ribbon of the type used in typewriters.

Printing wheel 554 is provided on its cylindrical surface with symmetrical spiral knife edges 565, (Fig. 6), which are normally substantially in contact with the tapes.

Under the tapes and opposite printing wheel 554 is the operating member or platen 566 having knife edge 567 arranged transversely at a slight angle with respect to the tapes as will more fully hereinafter appear. Member 566 is attached to an armature member 568 of cup form supported upon a spring mounting 569 which carries the recorder operating winding 470. Receiver field magnet 575 has winding 577 and core 576 having extension poles 578 which terminate closely adjacent to and the ends of which partially encompass and fit closely around winding 470. Field winding 577 is connected to battery 580 and is normally energized.

In Fig. 8, tapes 560 and 561 are shown as viewed from above in Fig. 6, and diagonal lines 585 show a development of edges 565 of printing wheel 554. Dotted line 567 is the edge 567 of the recording platen of Figs. 6 and 7, shown dotted because it is below the tapes 560 and 561. This

line, it will be noted is at a slight angle from the normal or transverse line of the tape. At 586 are shown the printed lines which compose the ultimate record, as will appear in the description of the operation.

Receiver operation

In operation of the receiver so far described, wheel 554 is driven constantly at a proper recording speed as will more fully hereinafter appear, and received current impulses impressed upon the operating winding 470 are in such a direction as to move cup-shaped armature 568 carrying armature member 566 upwardly, by cooperation with the force of the field of magnet 575, marking signal current repels against field force of magnet 575 and winding 470 is propelled upward. In absence of marking signal current, mounting spring 569 draws edge 567 downward and relieves pressure from tape 560. In double current working a reverse-polarity spacing signal current cooperates with field force of magnet 575 to assist spring 569, or to obviate this spring.

From Fig. 7 it will be noted that upward movement of armature member 566 causes engagement of knife edge 567 against the under surface of tape 560 pressing it with transfer paper 561 between edge 567 and spiral edges 565 on rotating receiver wheel 554.

From developed Fig. 8 it will be seen that the spirals 565, represented in this figure by lines 585, are so arranged that two of the spirals intersect a line drawn perpendicular to the edge of the tape. Lines 585 which represent spiral edges 565 will have a motion over the tape 560 in the direction of the arrow 587, due to rotation of wheel 554, while tape 560 has a slower motion in the direction of arrow 590 due to turning of roller 557.

Should armature 566 be operated vertically by an incoming signal impulse when knife edge 567 is in the relative position shown in dotted lines in Fig. 8, two dots will be printed upon the tape 560 at the two points where said knife edge 567 intersects spiral edges 585, or at points 567A, 567B. Should this vertical movement of knife edge 567 be repeated a brief interval later, a pair of dots will again be printed, but above the first pair of dots 567A and 567B because of the intervening movement of the tape and of spiral edges 585. If a letter is to be transmitted having a long vertical portion, such as the letter R, the knife edge 567 will be held in raised position by a comparatively long signal when the line is to be recorded so that each spiral line 585 will move to the right of Fig. 8 a distance such that any intersecting point will in effect, move vertically half the width of the tape. If an incoming signal is received when the edge 567 occupies the position shown dotted in Fig. 8, a vertical line will be marked on the tape 560 from 567A nearly to 567B, due to the movement to the right of spiral edge 585 contacting continuously with 567. A vertical line will also be drawn from 567B to the top of the wheel 554 and from the bottom of wheel 554 almost up to 567A, as seen in the letter R at the left side of the tape. Owing to the comparatively slow but continuous motion of the tape 560 the lines printed thereupon do not coincide exactly with the edge 567 but are normal to the edge of the tape or in the direction of lines 586 of Fig. 8.

The vertical line so recorded on the tape will correspond to black unit areas extending from point 237 to point 238 of Fig. 13, and will be transmitted by engagement of one of the brushes 200 with portion 237A of the R disc (Fig. 12. Further movement of the R disc at the transmitter will result in non-contacting relation of the brush corresponding to low portion 243, then contact with high portion 239A, then non-contact with low portion 243, then contact with high portion 241A, then non-contact with low segment 254 in Fig. 12 and the successive contacting for the two high portions 211 spaced by the non-contacting segment 255. These long lines recorded from high portions 237A, 239A and 241A unite upon record tape 560 to form the stem portion of letter R being recorded. The two smaller contacting portions 211 will result in four dashes or lines adjacent the vertical lines on the tape 560 which will thus begin the horizontal portions of the letter R as seen in Fig. 13, it being understood that the equivalent of two R's is being printed. Continued rotation of the R disc will transmit signalling impulses spaced by proper blank signals to develop the letter R in one complete and two fractional characters on the tape 560. In the same manner each character to be transmitted is developed by successive impulses received from the selective code discs upon the coil 470 of the receiving instrument.

Should knife edge 567 be held upwardly for a long period of time, for example, while one of the spiral lines 585 passes completely over the knife edge 567, successive vertical lines would be printed upon the tape 560 by the passage of successive edges 585 of the printing wheel and would produce substantially a solid printing upon the tape.

Since a continuous transmitted current or marking condition would produce a succession of these vertical black lines which would thus blacken the entire surface of the record tape, and since the omission of a current or transmission marking will leave a blank space or light areas, legible records may be produced by omitting the proper combinations of marking signals. The combinations of marking and spacing conditions necessary for each character to be transmitted are controlled by a code disc 201 individual thereto, the proper code disc being selected by selection of its brush 200 under control of the transmitting tape.

Spacing between letters, as previously explained, is produced by the initial omission of current or transmission of a spacing signal preceding each character transmitted.

As previously stated, due to the overlap of the spiral knife edges 565, a double record will be produced on tape 560 as shown in tape 591 of Fig. 9. It will be clearly understood that a receiver to reproduce three or more lines of characters may be attained by providing spiral knife edges 565 so that a larger number of these edges overlap at all points and a proper adjustment of speed of wheel 554.

Duplicate records may also be secured by providing a plurality of tapes 560 each having a transfer or carbon paper 561 superimposed one upon the other in a manner well known in the typewriting or telegraph art.

Synchronization

The improved duplicate record recorder permits wide variations in receiver and transmitter speeds without loss of signals and permits the use of novel methods of speed control for practical operation without the necessity for special control or synchronizing signals or devices. This is due

to the fact that at least one complete character is always received and the position of the characters on the receiving record indicates the synchronous or asynchronous condition of the apparatus and an operator can, without interruption of signalling, visually note deviations of the receiver from synchronism, and can adjust the receiver speeds without loss of signals.

If the speed and phase of rotation of printing wheel **554** correspond exactly to the speed of rotation and phase of the transmitting code discs, the record will be received as shown upon tape **591** of Fig. 9, as one complete set of characters uniformly spaced from the edges of the receiving tape and two fractional rows. Should the speed of wheel **554** be faster than that of code discs of the transmitting instrument, the record will be received as shown on the tape **592** of Fig. 10. If the speed of the receiver is slower than the transmitter the resultant record will be as shown upon the tape **593** (Fig. 11). A continuance of the effect shown in Fig. 11 would carry the median row of characters to the lower edge of the record tape where the reader would then cease to read one line of characters and would begin to read the next vertical line thereof.

The most important feature of the two letter method of recording is the elimination of all control between the sender and receiver. This is very desirable in radio transmission since foreign impulses such as static cannot interfere with the proper and legible placing of the letter on the record tape. Should the effect repeat itself persistently, the speed of the vibrator at the receiving station may be manually adjusted to restore the receiver as closely as desired to synchronous speed by movement of the rheostat **545**, as described in connection with Fig. 14, during reception and without loss of signals.

Referring to the photographic recorder or receiver of Fig. 16, adjustable governor shaft **552** of Fig. 14 appears in Fig. 16 and bears scanning disc **910** and gear **911**, in mesh with gear **912** on shaft **913**. Gear **914** on shaft **913** meshes with gear **915** on shaft **916**, which bears roller **917** which in turn cooperates with a companion roller **918**. Tape **919** passes between rollers **917** and **918** and then passes through tank **920**. At **921** are shown undeveloped photo effects and at **922** are shown developed characters upon the tape **919**.

In disc **910** are a number of holes **930** arranged in a circular arc. A system of optical condensers **931** is positioned upon an axis **932** preferably parallel to the axis of shaft **552**, and intersecting the path of holes **930**, and also intersecting tape **919**.

Neon lamp **933** is positioned on axis **932** and optical condensers **931** are arranged to throw a beam of light **932A** on disc **910** whose diameter is at least equal to and preferably is slightly greater than the spacing between three holes **930**. There are thus at least two holes within the area **932A** of the light beam at all times and a signal pulse cannot be lost. If this provision was not made, exact synchronism of the transmitter and recorder would be necessary or else some light impulses would be received when there was no hole in the area of the light beam and there would be no corresponding record made.

By the arrangement described, a further advantage is obtained in that duplicate records are printed as shown on tape **922** so that if transmitter and receiver are not in exact synchronism, at least one complete and legible message will be printed.

If the receiver is running out of synchronism, as disclosed by an examination of the tape, the orientation adjustment shown in Fig. 15 can be manually adjusted to obtain the printing of the record with one full row of characters in the center of the tape and synchronous speed may be easily maintained by this adjustment.

The neon lamp **933** is connected in series with battery **936**, resistance **937** and wire **938**. Battery **936** is connected through battery **939** to filament **940**, heated by battery **941** and forming a part of thermionic valve **942**. Wire **938** is connected by wire **943** to plate **944** of valve **942**. Grid **945** of valve **942** is connected through battery **946** to induction coil **433** and filament **940**, which is also connected by wire **947** to induction coil **433**.

The spacing of holes **930** in disc **910** is slightly greater than the height of the symbols or letters on tape **919**. This has the effect of giving a blank space between vertical rows of letters on receiver tape **919**, similar to the record shown in Fig. 9.

Operation of the receiving apparatus, Fig. 16, begins with the action of repeating coil **433**, which in accordance with the received signals impresses an alternating current upon grid **945** and filament **940** of valve **942**, through wire **947** and battery **946**.

The source from which the signals are sent and the communication channels over which the signals are propagated to reach the induction coil **433**, is not of the essence of the description in the study of this figure, since the signals may originate in a device modeled upon the disclosure of Fig. 1, or any other suitable transmitting mechanism.

The signals impressed upon grid **945** are alternating in nature and of voice frequency. These signals are repeated in amplified intensity over the discharge circuit comprising battery **939**, filament **940**, plate **944**, wire **943**, wire **938**, neon lamp **933** and battery **936**. There is also the derived circuit or shunt **937**, which reduces the current through lamp **933** and which preserves the continuity of the current through plate **944** during periods of inactivity of lamp **933**. The circuit including battery **936**, resistance **937**, wire **938** and lamp **933** provides for lamp **933** a potential nearly sufficient, yet insufficient, to operate lamp **933**. When the plate current of valve **942** increases, the potential upon lamp **933** is raised to operating value and lamp **933** glows. On the other hand when due to the control of the grid **945**, plate current from valve **942** decreases, potential upon lamp **933** is decreased and the lamp darkens. Each positive pulse of voice frequency upon grid **945** thus propagates a signal to flash lamp **933**, which responds with rapid flashes of voice frequency when current is received from induction coil **433**, and which remains dark when no such current is received. By the flashing of lamp **933**, light is supplied to the system of optical condensers **931**, and a beam of light **932A** is impinged upon disc **910** and passes through two holes to impinge in two places upon the photo-sensitive recording tape **921**. By motion of the tape and the regulated speed of disc **910**, letters will be formed in latent photographic images **921**, upon the moving tape **919**, which then passes through the developing tank **920** of any suitable type, and emerges with a visible record, as shown in characters **922**. The nature of the record is similar to that discussed in connection with Figs. 9, 10, and 11, and is subject to the same corrective measures. The shaft **552** is subject to the correc-

tive measures discussed in connection with Figs. 14 and 15.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. A method of operating a facsimile telegraph system, which comprises simultaneously recording a plurality of images in adjacent relationship on a single strip of recording medium of each transmitted character whereby legible records are received with wide variations in the speeds of operation of transmitting and receiving mechanism.

2. In a facsimile telegraph system, a printing receiver, a tape, and means to print thereon in adjacent relationship at least two duplicate received characters of each transmitted character whereby the received message is fully legible when the receiver is not in synchronism with its transmitter.

3. In a facsimile telegraph, a receiver having signal responsive means for flashing a light ray, a light sensitive element, and means to impinge said light ray on said sensitive element at a plurality of points to facsimile in duplicate a received symbol.

4. In a facsimile telegraph receiver, a light sensitive element, means responsive to received signals for impinging a light ray thereon, a perforated disc positioned in the path of said light ray, the perforations in said disc being so spaced that said ray always passes through two perforations to said light-sensitive element, whereby duplicate symbols are reproduced thereon.

5. In a facsimile telegraph system, transmitting apparatus, receiving apparatus, means to simultaneously produce upon one record a plurality of images of each transmitted character whereby legible records are received substantially independent of speed control between the transmitting and receiving apparatus.

6. In apparatus for transmitting and recording images, the combination of a transmitter comprising a rotating image record, means for scanning each element of the image record to produce corresponding electrical impulses, a recording device comprising a support for an image record receiving element, and means cooperating with said record receiving element and responsive to the transmitted electrical impulses for recording each transmitted element of the image twice in adjacent relation and spaced to produce duplicate images, whereby one of the two recorded images will be uninterrupted.

7. In apparatus for transmitting and recording images, the combination of a transmitter comprising an image record, means for scanning each element of the image record to produce corresponding electrical impulses, a recording device comprising a support for an image record receiving element, and means cooperating with said record receiving element and responsive to the transmitted electrical impulses for recording each transmitted element of the image simultaneously in duplicate in adjacent relation and spaced to produce duplicate images, whereby one of the two recorded images will be uninterrupted.

8. In a facsimile telegraph, a receiver having means to produce a light ray to record characters, a light sensitive recording element, and means to impinge said light ray on said recording element at a plurality of points farther apart than the vertical dimension of a recorded character to facsimile in duplicate a received character with separation between the duplicate records.

9. In a facsimile telegraph receiver, a light sensitive element, means responsive to received signals for impinging a light ray thereon, and a perforated disc positioned in the path of said light ray, the successive perforations in said disc being spaced closer together than the width of a receiving tape, thereby presenting two light rays through two perforations simultaneously to said light sensitive element.

10. In a facsimile telegraph receiver, a light sensitive element, means responsive to received signals representing characters for impinging light rays thereon, and a perforated disc positioned in the path of light whose perforations permit rays of light through said disc to impinge upon said light sensitive element, the successive perforations in said disc being closer together than the width of said light sensitive recording element and farther apart than the height of said characters represented by received signals whereby duplicate characters are produced with separation between duplicates.

11. In a facsimile telegraph system, transmitting apparatus, receiving apparatus, and means to record simultaneously on a single strip of recording medium a plurality of images of each transmitted character separated and in different planes whereby legible records are received substantially independent of speed control between transmitting and receiving apparatus.

12. In a facsimile recorder for recording simultaneously a plurality of parallel lines on a recording tape, means for moving the tape continuously, a rotating printing wheel, and a recording edge cooperating with said wheel for printing set at an angle to said parallel lines, said angle being such that the difference between the rotation of the wheel and the movement of recording tape is compensated.

13. In a facsimile recorder, a cylindrical recording member having spiral edges, and a recording member having a straight edge, the angle of said spiral edges being such that two or more spiral edges engage said straight edge at one time.

14. In a facsimile recorder, means to record multiple images upon a recording surface to appear as a complete image accompanied by fractional images above and below the complete image, and manual control means for shifting the position of the currently received image with reference to the edges of the surface and without stopping the operation of the recording means.

15. A method of operating a facsimile telegraph system which comprises, simultaneously recording in a plurality of places upon a single record surface to produce a single complete image and a plurality of fractional images of each transmitted character, whereby legible records are produced despite wide differences between speeds of transmitting and receiving mechanisms.

16. In a telegraph system, a printing receiver, a tape, and means to print simultaneously in a plurality of spaces on said tape to produce one complete record and a plurality of mutilated records of a character corresponding to a received code signal when the receiver is out of phase with said received code signal.

17. In a facsimile telegraph system, transmitting apparatus, receiving apparatus, means to produce simultaneously upon one record a plurality of images comprising one perfect image and two fractional images of each transmitted character whereby legible records are received substantially independent of speed control between the transmitting and receiving apparatus.

18. In apparatus for transmitting and recording images, the combination of a transmitter comprising a rotating image record, means for scanning each element of the image record to produce corresponding electrical impulses, a recording device comprising a support for an image record receiving element, and means cooperating with said record receiving element and responsive to the transmitted electrical impulses for recording each transmitted element of the image twice in adjacent relation and spaced to produce a plurality of images when said receiver is out of phase with said transmitter, said record receiving element having an image recording receiving area greater than the area of any recorded received image, whereby one of the recorded images will be uninterrupted.

19. In apparatus for transmitting and recording images, the combination of a transmitter comprising an image record, means for scanning each element of the image record to produce corresponding electrical impulses, a recording device comprising a support for an image record receiving element, and means cooperating with said record receiving element and responsive to the transmitted electrical impulses for recording each transmitted element of the image simultaneously in duplicate in adjacent relation and spaced to produce a perfect image in a mean position accompanied by mutilated duplicate images, whereby one of the recorded images will be legible.

20. In a facsimile telegraph, a receiver having means to produce a plurality of light rays to record characters, a light sensitive recording element, and means to impinge said light rays on said recording element at a plurality of points farther apart than the vertical dimension of a recorded character to facsimile a received character accompanied by fragmentary duplications thereof with separation between the recorded facsimile character and the fractional duplicate records.

21. In a facsimile telegraph system, transmitting apparatus, receiving apparatus, and means to record simultaneously a plurality of images of each transmitted character separated and in different axial zones upon a tape whereby legible records are received substantially independent of phase control between transmitting and receiving apparatus.

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